LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA13 | Calvert, Steeple Claydon, Twyford and Chetwode

Flood risk assessment (WR-003-013)

Water resources

November 2013

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Department for Transport

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High Speed Two (HS2) Limited,
Eland House,
Bressenden Place,
London SW1E 5DU

Details of how to obtain further copies are available from HS2 Ltd.

Telephone: 020 7944 4908

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise four parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Specific appendices for each community forum area (CFA) are also provided. For the Calvert, Steeple Claydon, Twyford and Chetwode area (CFA13) these are:

- a water resources assessment (Volume 5: Appendix WR-002-013);
- a flood risk assessment (i.e. this appendix); and
- a hydraulic modelling report for the Padbury Brook at Twyford and Godington (Volume 5: Appendix WR-004-004).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Scope of this assessment

1.2.1 This flood risk assessment (FRA) considers the assessment of flood risk in CFA13. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1] which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

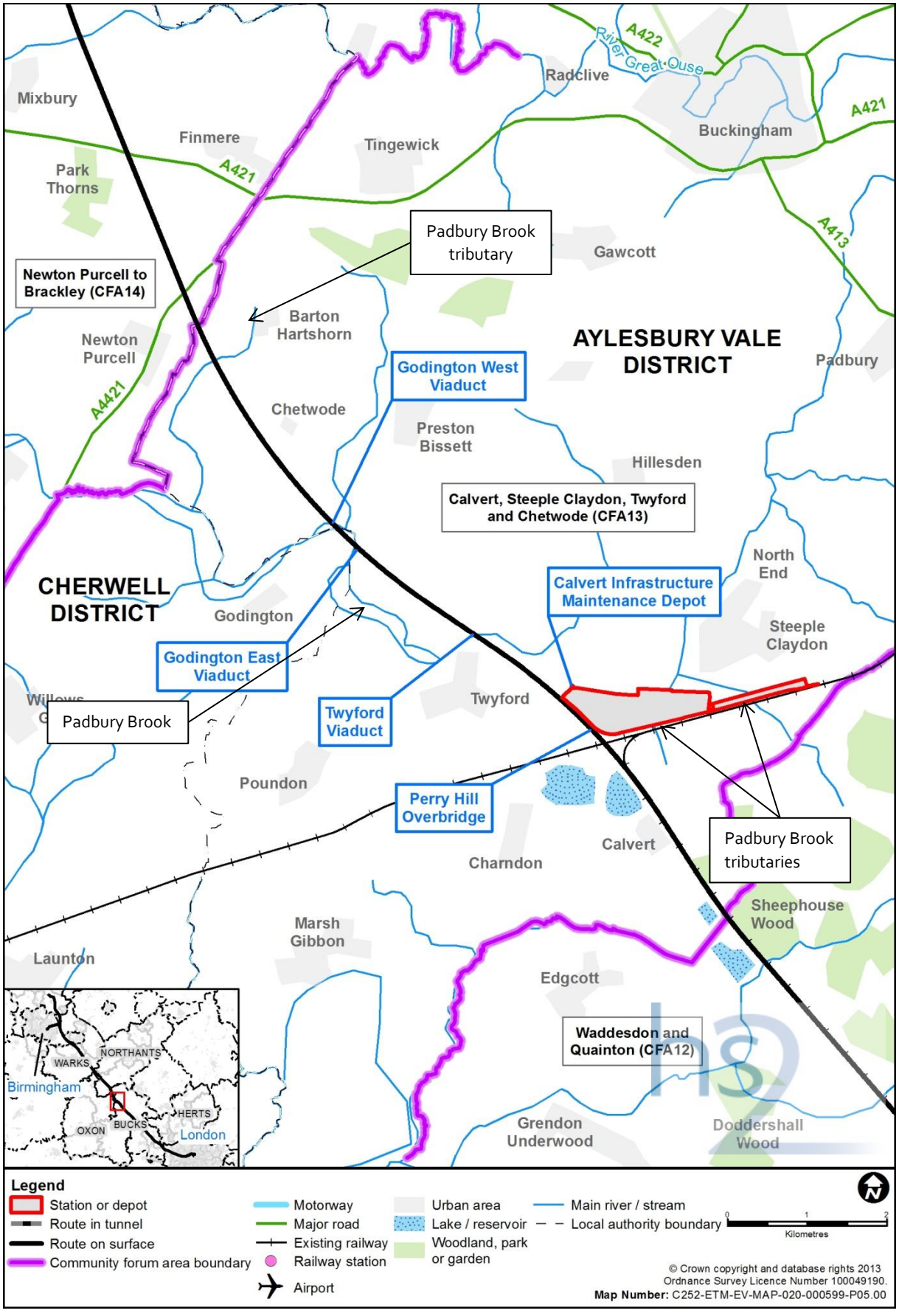
1.2.2 The FRA methodology and a review of the relevant local planning policy documents are provided in Section 2 of this report. The design criteria are provided in Section 3 and Section 4 documents the sources of information that have been reviewed. Section 5 provides a description of the planned works within CFA13. Section 6 considers baseline flood risk and the risk of flooding to the Proposed Scheme from all relevant sources. Flood risk mitigation measures included within the Proposed Scheme are detailed in Section 7. The effect of the Proposed Scheme on the risk of flooding is considered in Section 8.

1.3 Location

1.3.1 CFA13 covers an approximately 10km section of the Proposed Scheme in the Aylesbury Vale and Cherwell district councils within the counties of Buckinghamshire and Oxfordshire. It extends from the Calvert Green parish boundary in the south to the Barton Hartshorn parish boundary in the north as shown in Figure 1. The Waddesdon and Quainton area (CFA12) and the Newton Purcell to Brackley area (CFA14) lie to the south-east and north-west respectively.

[1] Department for Communities and Local Government (2012), *National Planning Policy Framework*.

Figure 1: Calvert, Steeple Claydon, Twyford and Chetwode area



1.3.3 The study area extends to a distance of 1km from the centre line of the Proposed Scheme and includes the parishes of Waddesdon, Quainton, Westcott, Grendon Underwood, Middle Claydon, Edgcott and Calvert Green. The corresponding council wards are Waddesdon, Quainton, Grendon Underwood, Steeple Claydon and Marsh Gibbon.

1.3.4 The route will cross a number of water features within the study area, as identified using the surface water crossing (SWC) references on Map WR-01-017 and Map WR-01-018 (Volume 5, Water Resources and Flood Risk Assessment Map Book) comprising the Padbury Brook and its tributaries and associated floodplains (SWC-CFA13-01 to SWC-CFA13-11, SWC-CFA13-16 and SWC-CFA13-17).

2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model, individual sources of flooding within the study area are identified. The primary source of flooding is rainfall which is a direct source in the short-term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewer flooding) in the short or medium-term. Stored rainfall, either naturally in below ground aquifers and natural lakes or artificially in impounded reservoirs and canals can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea.

2.1.2 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.3 Receptors considered in this assessment include the Proposed Scheme and existing development within 1km of the Proposed Scheme. The Proposed Scheme includes all associated permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified, mitigation is proposed in line with recommendations in the NPPF.

2.1.4 Existing receptors within the study area are identified using Ordnance Survey (OS) mapping information. A high-level screening assessment is then undertaken to identify receptors that are within or in close proximity to an area of flood risk via pathways indicated using the flood risk data sources listed below. The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.5 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the Proposed Scheme has any potential to influence or alter the risk of flooding to each receptor. Where such potential has been identified, mitigation is proposed based on further analysis.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

[2] Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance.*

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Rivers		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water	No surface water flooding.	Surface water flooding <0.3m for 1 in 200 years event.	Surface water flooding >0.3m for 1 in 200 years event; and Surface water flooding <0.3m for 1 in 30 years event.	Surface water flooding >0.3m for 1 in 30 years event.	
Groundwater		Very low-low	Moderate	High-very high	
Drainage and sewer systems	No sewer in vicinity of site.	Surcharge point >20m from site and no pathways.	Surcharge point within 20m of site and restricted pathways.	Sewer network crosses site and pathways exist.	
Artificial sources	Outside of inundation mapping/no pathway exists.	Within inundation mapping/ pathway exists.			

2.3 Regional and local flooding planning policy documents

2.3.1 The lead local flood authorities (LLFA) for the study area are Buckinghamshire County Council (BuCC) and Oxfordshire County Council (OCC). The recommendations from the BuCC[3] and OCC[4] preliminary flood risk assessment (PFRA) reports undertaken in accordance with the Flood Risk Regulations 2009[5] have been reviewed in undertaking this assessment.

2.3.2 The BuCC draft local flood risk management strategy (LFRMS)[6] is at the consultation stage and was published in February 2013. The LFRMS for OCC is still in development.

2.3.3 The local planning authorities for CFA13 are Aylesbury Vale District Council (AVDC) and Cherwell District Council (CDC). The AVDC core strategy[7] (referred to as the Vale of Aylesbury Plan) is at the consultation stage. In addition, the 2011 Cherwell Local Plan[8] has been reviewed where relevant to water and flood risk. The Aylesbury Vale[9] and Cherwell and West Oxfordshire[10] strategic flood risk assessment (SFRA) reports

[3] Jacobs (2011), *Buckinghamshire County Council Preliminary Flood Risk Assessment.*
[4] JBA (2011), *Oxfordshire Preliminary Flood Risk Assessment*
[5] *Flood Risk Regulations 2009* (SI 2009 No.3042). London, Her Majesty's Stationery Office
[6] Buckinghamshire County Council (2013), *Buckinghamshire County Council Local Flood Risk Management Strategy 2013 – 2018.*
[7] Aylesbury Vale District Council (2013), *The Vale of Aylesbury Plan Strategy 2011 – 2031 Proposed Submission (2013).*
[8] Cherwell District Council (2011), *Cherwell Local Plan*.
[9] Aylesbury Vale District Council (2012), *Aylesbury Vale Strategic Flood Risk Assessment* (Revised from: Royal Haskoning (2007)).
[10] Scott Wilson (2009), *Cherwell and West Oxfordshire Strategic Flood Risk Assessment*.

have been used as context and to provide baseline data for the assessment of flood risk within CFA13.

2.3.4 The route passes through the management areas of the Buckingham and River Ouse Internal Drainage Board, which is a member of the Bedford Group of Internal Drainage Boards and is hereafter referred to as the Bedford Internal Drainage Board. Land drainage is managed by the Bedford Internal Drainage Board at Calvert, Steeple Claydon, Twyford, Godington and Newton Purcell and the route will cross the Padbury Brook and its tributaries which are subject to Bedford Internal Drainage Board's statutory and byelaw control.

Buckinghamshire County Council Preliminary Flood Risk Assessment

2.3.5 The PFRA confirms that there are no indicative flood risk areas of national significance within the Buckinghamshire area. Consequently, only Stage 1 of the Flood Risk Regulations 2009[11] process (i.e. the PFRA) has been completed.

2.3.6 The BuCC PFRA recognises that the construction and engineering of Proposed Scheme may have a significant impact upon surface water flows. For example embankments and cuttings may, without suitable design solutions, impede the flow of small watercourses and surface runoff.

Buckinghamshire County Council Local Flood Risk Management Strategy

2.3.7 The BuCC LFRMS guides the planning process in relation to flood risk across all categories. The BuCC LFRMS outlines key policies in relation to development within Buckinghamshire. Specific policies of relevance to the Proposed Scheme are:

- Policy 6 – the LLFA will seek to reduce the risk of flooding now, in a way which does not compromise the interconnected needs of the economy, society and environment in the future; and
- Policy 15 – sustainable drainage systems (SuDS) should be used in new developments to reduce the rate and volume of surface water runoff. Design of SuDS to meet national standards and be adopted by the SuDS Approval Body. SuDS are expected to provide natural removal of pollutants and sediments, promote aquifer recharge, enhance biodiversity, add aesthetic value and be easily maintainable.

Great Ouse Catchment Flood Management Plan

2.3.8 The watercourses within CFA13 fall within the Great Ouse Catchment Flood Management Plan (CFMP)[12] which covers the risk extent from rivers of the Great Ouse basin. The rivers in the study area fall within the Bedford Ouse rural and eastern rivers policy area where Policy 3 is applied i.e. areas of low to moderate flood risk where the Environment Agency is generally managing existing flood risk effectively. The policy enables the LLFA (and Environment Agency, where appropriate) to continue to manage flooding through existing management actions.

[11] *Flood Risk Regulations 2009* (SI 2009 No. 3042), London, Her Majesty's Stationery Office.
[12] Environment Agency (2011), *Great Ouse Region Catchment Flood Management Plan.*

Aylesbury Vale Water Cycle Strategy

2.3.9 The Aylesbury Vale Water Cycle Strategy[13] (WCS) reviews flood risk management planning policy relevant to Aylesbury Vale and outlines location specific concerns regarding flood risk management. The WCS identifies significant risks of river flooding on the Padbury Brook (referred to as 'The Twins') and its tributaries, particularly within Padbury, Chetwode, Steeple Claydon, Thornborough and Middle Claydon. All proposed developments in the Aylesbury Vale area will require detailed drainage strategies and SuDS proposals including proposals outside of any identified flood risk area.

Aylesbury Vale Strategic Flood Risk Assessment

2.3.10 The Aylesbury Vale Level 1 SFRA includes advice on planning policy within the development area and is often used as a basis for policy setting and planning decisions.

2.3.11 Historical flooding records collected within the Aylesbury Vale SFRA from the Environment Agency, AVDC, Bedford Internal Drainage Board, Thames Water Utilities Limited and Anglian Water include flooding from the Padbury Brook within fields at Twyford, Three Bridge Mill and Twyford Mill.

2.3.12 The Aylesbury Vale SFRA identifies the need for surface water management in the district due to concern over flooding within the Great Ouse downstream particularly at Buckingham. Infiltration based SuDS are preferred as a means of surface water management and ground investigations are required to determine the feasibility of such techniques. In addition opportunities are sought to enhance and supplement the existing flood storage and alleviation measures already in place for AVDC. SFRA policy indicates that:

- management of surface runoff should use site specific and strategic SuDS measures encouraging source control where possible; and
- proposed infrastructure should avoid interference with floodplain flow and storage where they cross existing river valleys unless they are also specifically designed as part of the strategic flood risk management options. Consultation with the Environment Agency is essential in such cases.

Vale of Aylesbury Plan

2.3.13 The Vale of Aylesbury Plan[14] is in the consultation stage. Objective 7 which covers adaptation to and mitigation against climate change is of specific relevance to flood risk and development covering the following points:

- no built greenfield development to take place in the functional floodplain and/or Flood Zones 2 or 3, other than for essential strategic infrastructure; and
- improved flood protection including more effective use of multi-functional green spaces which can assist in flood control.

[13] Halcrow (2012), *Aylesbury Vale Water Cycle Strategy*.
[14] Aylesbury Vale District Council (2013), *The Vale of Aylesbury Plan Strategy 2011 – 2031 Proposed Submission 2013*.

2.3.14 Policy VS11 sets out the position of the AVDC towards protection of environmental assets, with a focus on maintaining watercourses and their settings for their biodiversity and recreational value, as well as incorporation of SuDS and flood storage areas to reduce downstream flood risk.

Oxfordshire County Council Preliminary Flood Risk Assessment

2.3.15 The OCC PFRA confirms that there are no indicative flood risk areas of national significance within the Oxfordshire area. Consequently, only Stage 1 of the Flood Risk Regulations 2009 process (i.e. the PFRA) has been completed. The PFRA indicates that groundwater and surface water are the major sources of flood risk (excluding rivers) within the county, although surface water flooding is noted to be of most concern within the urban centres.

2.3.16 The OCC PFRA contains an overarching policy that seeks to ensure that development does not increase local flood risk. The guidance states that in exceptional circumstances flood risk can be increased contrary to Government policy because of the wider benefits. Any exceptions will not be expected to increase risk to levels which are significant in terms of the Government's criteria.

Cherwell and West Oxfordshire Strategic Flood Risk Assessment

2.3.17 The Cherwell and West Oxfordshire joint SFRA, released in 2009, promotes the use of SuDS to counteract the effects of climate change on the risk of flooding. Although acknowledged as a notable source of flooding in the district, the Great Ouse catchment is not covered in detail, since the River Cherwell has historically been the more significant source of flooding. Management of future flood risk is promoted through the protection of floodplains from development (with a specific reference to the use of level-for-level replacement floodplain storage where floodplain development is inevitable) and the restoration of river corridors. The Cherwell and West Oxfordshire joint SFRA recommends that strategic infrastructure is located within areas with the lowest risk of flooding.

Cherwell Local Plan

2.3.18 The 2011 Cherwell Local Plan has been approved as an interim planning policy for development control purposes, despite being a non-statutory document. Policy EN12 of the non-statutory Cherwell Local Plan seeks to prevent development which will harm the quality of underground or surface water bodies. Cherwell Policy EN13 seeks to protect river corridors and watercourses. The intent of Cherwell Policy EN14 is to prevent development in areas at risk of flooding, whilst Policy EN15 seeks to limit the potential for surface water runoff.

2.3.19 Overarching Policy ESD 1 of the CDC Local Plan (Proposed Submission Focus Document 2013) states that proposed development will be required to minimise the risk of flooding and make use of sustainable drainage methods. Policy ESD 6 expands on this to specifically promote SuDS and flood risk management through the protection of river corridors together with de-culverting and floodplain restoration. Specific guidelines for development are included as follows:

- "flood risk assessments should assess all sources of flood risk and demonstrate

that there will be no increase in surface water discharge rates or volumes during storm events up to and including the 1 in 100 year storm event with an allowance for climate change (the design storm event)";

- "developments will not flood from surface water up to and including the design storm event or any surface water flooding beyond the 1 in 30 year storm event up to and including the design storm event will be safely contained on site"; and
- "development should be safe and remain operational (where necessary) and proposals should demonstrate that surface water will be managed effectively on site and that the development will not increase flood risk elsewhere, including sewer flooding."

2.3.20 Policies ESD 3 and ESD 7 promote source control and SuDS as a means to combat future increases in flood risk arising from climate change and as a proactive means of reducing downstream flood risk. Policy SLE 5, specific to the Proposed Scheme, states that "the design and construction of the High Speed 2 Rail Link must minimise adverse impacts on the environment [...] and maximise any benefits that arise from the proposal".

Bedford Group of Internal Drainage Boards

2.3.21 The Wildlife Conservation and the Environmental Strategy of the Bedford Group of Internal Drainage Boards[15] includes policies ensuring that water level management plans for development sites are completed, implemented as appropriate and reviewed in accordance with the Department for Environment, Food and Rural Affairs (Defra) targets.

2.3.22 The Bedford Group advises local planning authorities as to the appropriate surface water and flood risk management measures required for development within the drainage district.

2.3.23 Works on watercourses within the Internal Drainage Board area of control are subject to the Bylaws[16], including:

- "No person shall in the flood plain of any watercourse without the previous consent of the Board construct, erect or form or cause to be constructed, erected or formed, any structure or deposit or cause to be deposited any material or form or cause to be formed any heap of materials, which is or are of such a size or nature or is or are placed in such a position or positions as to be likely to divert or obstruct the flow of water in the flood plain and to affect adversely the efficient drainage of the floodplain or any part or parts of the Board's area."

[15]Bedford Group of Internal Drainage Boards; Wildlife Conservation and the Environmental Strategy of the Bedford Group of Internal Drainage Boards; www.idbs.org.uk/about-us/environmental-strategy-wildlife-conservation/, accessed: 7 October 2013.
[16] Buckingham and River Ouzel Internal Drainage Board (1985), *Buckingham and River Ouzel Internal Drainage Board Bylaws.*

3 Design criteria

3.1.1 It is a requirement of the design that the Proposed Scheme shall be protected against flooding from any source during the 1 in 1000 years return period (0.1% annual probability) rainfall event, with water levels not rising closer than 1m to the top of rail level.

3.1.2 In accordance with the NPPF an allowance for climate change is included in the assessment by assuming that peak rainfall intensity will increase by 30% and that peak river flows will increase by 20%.

4 Data sources

4.1 Primary datasets

4.1.1 Consistent with the requirements of the NPPF, this assessment considers the risk of flooding from rivers, direct surface water runoff, rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The Proposed Scheme lies entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are presented in Table 2. A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the route, further investigation in the form of hydraulic modelling is undertaken.

Table 2: Flood risk assessment data sources

Source of flooding	Datasets reviewed	Data owner
Rivers	Flood zone mapping. Detailed River Network (DRN). Catchment hydraulic models.	Environment Agency
Surface water	Flood Map for Surface Water (FMfSW). Local surface water flood mapping.	Environment Agency LLFA
Groundwater	Areas susceptible to groundwater flooding. 1:50,000 geological mapping (superficial and bedrock). Potential for elevated groundwater.	British Geological Survey (BGS) LLFA
Drainage and sewer systems	Sewer network plans. Lost river location plans.	Water companies (various) Local planning authority
Artificial sources	Reservoir inundation mapping (RIM). Canal infrastructure locations. Trunk water main asset plans.	Environment Agency Canal & River Trust Water companies (various)

4.2 Site familiarisation visits

4.2.1 Site familiarisation visits have been carried out for key locations along the route where access has been granted. A site familiarisation visit was undertaken to the crossings of the Padbury Brook at Twyford and Godington in December 2012 and to the two watercourses south of Steeple Claydon at the Calvert infrastructure maintenance depot (IMD) in January 2013.

5 Proposed Scheme

5.1 Topography and land use

5.1.1 The topography within CFA13 is generally flat and becomes gently undulating in the north. The area is predominantly rural in character, with agriculture being the main land use, interspersed with small villages and a scattering of isolated dwellings and farmsteads. The Padbury Brook flows in an easterly direction, meandering between Twyford and Godington.

5.1.2 The land use is dominated by arable farming resulting in large field patterns with established hedgerow field margins. There is also some dairy farming, predominantly in the north of the area. The area is interspersed with some large pockets of ancient woodland, which are remnants of the Bernwood Forest.

5.1.3 There are a number of settlements within the area, the largest being Steeple Claydon, which lies to the east of the Proposed Scheme and north of the proposed IMD.

5.2 Local flood risk receptors

5.2.1 The vulnerability of each local receptor with an identified pathway within the study area is presented in Table 3. The vulnerability is classified in accordance with the recommendations of Table 2 in the NPPF Technical Guidance Document and the Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-000/1) and the SMR Addendum (see Volume 5: Appendix CT-001-000/2).

Table 3: Vulnerability of local receptors in CFA13

Local receptor	Description	Vulnerability classification	Source/pathway
Properties within the village of Calvert	Residential dwellings and associated buildings	More vulnerable	Surface water 200 years - deep Groundwater very high
Shepherd's Furze Farm	Agricultural land only (no buildings)	Less vulnerable	Surface water 30 years - deep
Agricultural land to the south of Steeple Claydon	Agricultural land only (no buildings)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Claydon Park Lower Lake Groundwater - very high
Elm Tree Farm	Agricultural land only (no buildings)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Claydon Park Lower Lake
Lake Farm	Agricultural land only (no buildings)	Less vulnerable	Surface water 200 years - deep
Portway Farm	Agricultural land only (no buildings)	Less vulnerable	Surface water 200 years - deep Groundwater - very high

Local receptor	Description	Vulnerability classification	Source/pathway
Properties on Portway Road	Residential dwellings	More vulnerable	Surface water 30 years - deep
Three Bridge Mill	Residential dwelling	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - shallow Tusmore Park Lake Groundwater - very high
Agricultural land east of Twyford (Home Farm)	Agricultural land and farm buildings	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater - very high
Playing Fields east of Twyford (off School Lane)	Playing fields	Water compatible	River flooding Flood Zone 3 Groundwater - very high
Properties within the village of Twyford	Residential dwellings	More vulnerable	Groundwater - very high
Agricultural land owned by Portway Farm (south of Padbury Brook at Twyford)	Agricultural land	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater - very high
Agricultural land north and west of Twyford (Church View Farm)	Agricultural land only (no buildings)	Less vulnerable	River flooding Flood Zone 3 Surface water 200 years - deep Groundwater - very high
Cowley Lodge Farm (north of Padbury Brook at Twyford)	Agricultural land only (no buildings)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake Groundwater - very high
The Bungalow (Cowley Lodge)	Residential dwelling	More vulnerable	Surface water 200 years - shallow
Cowley Old House	Residential dwelling	More vulnerable	Surface water 30 years - shallow
Cowley Farm	Agricultural land only (no buildings)	Less vulnerable	River flooding Flood Zone 3 Surface water 200 years - deep Tusmore Park Lake Groundwater - very high

Local receptor	Description	Vulnerability classification	Source/pathway
Twyford Mill	Primarily agricultural land with residential property and farm buildings	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake Groundwater - very high
Agricultural land east of Godington (Grange Farm)	Agricultural land only (no buildings)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake Groundwater - very high
Agricultural land north and east of Godington and north of the former Great Central Main Line (Casemore Farm)	Agricultural land only (no buildings)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake Groundwater - very high
Moat Farm	Residential dwelling and associated outbuildings, agricultural land and church	More vulnerable	River flooding Flood Zone 3 Surface water 200 years - shallow Tusmore Park Lake Groundwater - very high
Agricultural land and pasture surrounding Chetwode	Agricultural land, green open space	Less vulnerable	Surface water 30 years - deep Groundwater high
Watergate Farm	Residential dwelling and associated outbuildings and agricultural land	More vulnerable	River flooding Flood Zone 3 Surface water 200 years - deep Groundwater - very high
Agricultural land at Barton Grounds Farm	Agricultural land only (no buildings)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater - very high
Barton Grounds Farm	Residential dwelling and associated farm buildings	More vulnerable	Surface water 200 years - shallow Groundwater - very high
Barton Hill Farm	Residential dwelling and associated outbuildings and agricultural land	More vulnerable	Groundwater - high
Manor Farm, Barton Hartshorn	Residential dwelling and associated outbuildings and agricultural land	More vulnerable	Surface water 30 years - deep Groundwater - very high

5.3 Description of the Proposed Scheme

5.3.1 The Proposed Scheme through CFA13 will be approximately 10km in length. It will commence at the western edge of Sheephouse Wood to the south of Calvert and then proceed south-east to north-west parallel to the realigned Aylesbury Link railway line. It will then pass to the east of Calvert, under the realigned Bicester to Bletchley railway line, then west of Steeple Claydon, broadly following the alignment of the disused Great Central Main Line. The Calvert IMD will be located in the land adjacent to the Proposed Scheme, north-east of the Bicester to Bletchley railway line crossing, and the associated tracks will run west to east alongside the Bicester to Bletchley railway line for approximately 3km, approximately 600m south of Steeple Claydon. The design elements within this CFA are shown in Map Series CT-06-054 to CT-06-060 (Volume 2, CFA13 Map Book).

5.3.2 The Proposed Scheme will enter CFA13 on embankment at the same height as the existing Aylesbury Link railway line before dropping into cutting to pass under the Bicester to Bletchley railway line. The Aylesbury Link railway line will be realigned eastwards between Sheephouse Wood and the Bicester to Bletchley railway line. The Proposed Scheme will continue to follow the line of the former Great Central Main Line.

5.3.3 The IMD[17] at Calvert, a permanent land take of approximately 37ha, will occupy the north-eastern quadrant formed by the intersection of the Proposed Scheme and the realigned Bicester to Bletchley railway line. The IMD will operate as a base for maintenance activities to support the railway infrastructure. The Proposed Scheme will cross two ordinary watercourses south of Steeple Claydon at this location. To the south of the IMD, a sustainable placement area is proposed including a proposed diversion of the two branches of the existing watercourse at this location.

5.3.4 Continuing north, the Proposed Scheme will pass under the Bicester to Bletchley railway line and then begin to rise and diverge away from the former Great Central Main Line, which is disused north of Calvert. The Proposed Scheme will pass Twyford on a series of embankments, culverts and viaducts to cross the Padbury Brook, its tributaries and floodplains. The Proposed Scheme will then enter an approximately 1km long cutting, up to 5m deep, as it diverges to the east of Godington. A series of embankments, culverts and a viaduct is required to cross the Padbury Brook, its tributaries and associated floodplain. A combination of landscape embankments and noise barriers are proposed on the west side of the Proposed Scheme in the vicinity of Twyford.

5.3.5 To the north of Godington, for approximately 1.1km, the Proposed Scheme will pass along a series of embankments and two viaducts, as the Proposed Scheme crosses another meander of the Padbury Brook. After clearing the floodplain of the Padbury Brook, it will then be in cutting for approximately 1.9km, up to 10.5m deep in places, as the Proposed Scheme passes Rosehill Farm, Rosehill Cottages, Sunflower Cottage and Manthorn Farm along the edge of the hamlet of Chetwode. The Proposed

[17] Note that the IMD will also be used as part of the rail head during the construction phase, which will occupy a total area of 90ha for the construction period.

Scheme will then exit the cutting to re-join the former Great Central Main Line at the county boundary of Buckinghamshire and Oxfordshire, to the west of Barton Hartshorn.

6 Existing flood risk

6.1 Historical flooding incidents

6.1.1 The AVDC SFRA identifies specific historical flooding events within the study area, arising predominantly from the Padbury Brook. The CDC SFRA and BuCC PFRA also identify historical flooding incidents within the study area for this CFA.

6.1.2 River flooding was experienced from the Padbury Brook at Twyford, Twyford Mill and Three Bridge Mill in 2003 and flooding from an unknown source near Grebe Lake in Calvert in 2000. Historical flooding has also been recorded in 1947 where the route will cross the Barton Hartshorn tributary of the Padbury Brook.

6.2 Risk of flooding from rivers

6.2.1 Within CFA13, the main watercourse is the Padbury Brook and its tributaries, which will be crossed by the Proposed Scheme at a number of locations, as shown on Map WR-01-018 and Map WR-01-019 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The Padbury Brook, termed the 'Twin Rivers', is not a designated Environment Agency main river. The Padbury Brook and associated tributaries are managed by the Bedford Internal Drainage Board.

6.2.2 There are three crossings of the Padbury Brook and associated flood zones at Twyford (SWC-CFA13-04) and Godington (SWC-CFA13-08 and SWC-CFA13-09). These will be crossed by the Proposed Scheme on embankment with short viaducts through the floodplains. In addition, there are a number of crossings of tributaries to the Padbury Brook, including:

- at Grebe Lake (SWC-CFA13-01);
- at the Calvert IMD (SWC-CFA13-16);
- to the east of Twyford (SWC-CFA13-03) upstream of the confluence with the main channel; and
- near Barton Hartshorn (SWC-CFA13-11).

Padbury Brook tributary at Calvert IMD

6.2.3 The Calvert IMD will cross two tributary streams of the Padbury Brook on embankment to the south of Steeple Claydon (SWC-CFA13-15 and SWC-CFA13-16). The easterly of these watercourses (SWC-CFA13-16, referred to by the Bedford Internal Drainage Board as M24), which originates in the grounds of Claydon House, has an associated Environment Agency Flood Zone.

6.2.4 At this location the IMD will occupy approximately 8,600m^2 of Flood Zone 3. The upstream catchment draining to the crossing is 4.9km^2 according to the Flood Estimation Handbook (FEH) CD-ROM, resulting in a peak 1 in 100 years return period (1% annual probability) including a 30% allowance for climate change flow rate, of 7.2m^3/s (using the Revitalised Rainfall-Runoff Hydrograph (ReFH) method).

6.2.5 The Flood Zone Maps show a relatively consistent corridor of floodplain across the existing Bicester to Bletchley railway line embankment, however, the embankment is raised significantly above surrounding ground levels. Land to the north of the existing embankment is therefore partially protected against flooding from the upstream flows. The FMfSW shows a more accurate representation of the mechanisms of flooding in the area, as shown on Map WR-01-018, F3 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

Padbury Brook tributary at Twyford

6.2.6 The tributary to the west of Twyford (SWC-CFA13-03) has a catchment size of 3.6km^2 at the intersection with the Proposed Scheme. This tributary was removed from the Flood Zones in the latest Environment Agency modelling update.

Hydrology and hydraulic modelling

6.2.7 In view of the potential complexity of the Proposed Scheme design and the interaction of flood flows with existing structures in the floodplain, bespoke hydraulic modelling of the Padbury Brook between Twyford and Godington and this tributary has been undertaken as part of the FRA to define the baseline and assess the impact arising from the Proposed Scheme. A more detailed description of the hydrology and the modelling methodology can be found in Appendix Volume 5: WR-004-004. The impact on the risk of flooding in this location is discussed further in Section 8.

6.2.8 According to the bespoke modelling, the route will occupy approximately 18,100m^2 of Flood Zone 3 at the Twyford tributary.

6.2.9 The following floodwater levels were extracted from the hydraulic model at the Twyford east crossing of the Padbury Brook tributary:

- 1 in 100 year annual probability (1%) plus climate change stage of 83.40m above Ordnance Datum (AOD); and
- 1 in 1,000 year annual probability (0.1%) stage of 83.43m AOD.

Flood risk to Proposed Scheme

6.2.10 The route will be on embankment across the Padbury Brook tributary and its associated floodplain, with a 2.1m diameter box culvert to convey the watercourse beneath the Proposed Scheme. The top of rail level across the embankment is 86.1m AOD. The embankment and associated noise barriers form an obstruction to out of bank flows.

6.2.11 The maximum floodwater level upstream of the embankment for the tributary for the 1 in 1,000 years return period (0.1% annual probability) flood event is approximately 83.4m AOD. Therefore, there will be a 2.7m freeboard for the top of rail level of the Proposed Scheme and the maximum 1 in 1,000 years return period floodwater level. The Proposed Scheme will not be at risk of flooding from the Padbury Brook tributary at Twyford.

Padbury Brook at Twyford

6.2.12 The Proposed Scheme will pass over the twin channels of the Padbury Brook to the west of Twyford (SWC-CFA13-04 and SWC-CFA13-05), as shown on Map WR-01-018, C6 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

6.2.13 The Padbury Brook has a catchment size of approximately 73.8km^2 at this crossing, resulting in a 1 in 100 years return period (1% annual probability) flood flow of approximately 13.5m^3/s (calculated using the ReFH) at the crossing location. According to bespoke modelling of the Padbury Brook and its tributaries, the route will cross approximately 60m of Flood Zone 3 on viaduct, with embankments occupying approximately 7,000m^2 of Flood Zone 3 and 7,700m^2 of Flood Zone 2. According to the BuCC PFRA, historical flooding was experienced from the Padbury Brook at Twyford, Twyford Mill and Three Bridge Mill in 2003.

6.2.14 At the location of the crossing, there are two channels to the Padbury Brook. The eastern of the two channels is considerably larger than the western channel, with its natural water level higher than the surrounding topography through the use of bunds. This channel meanders considerably through this reach. The western channel is smaller and has been artificially straightened. Based on available light detection and ranging information, the eastern channel of the Padbury Brook is approximately 13m wide and the western stream approximately 5m wide, although it is skewed to the Proposed Scheme and therefore the skew width will be approximately 10m. The topography is generally flat in this location and is predominantly arable and agricultural land.

6.2.15 The preferential flow path for floodwater is between the two channels, close to the smaller western channel, in the slightly lower ground. Upstream of the potential crossing location there is an existing rail embankment. There is an underbridge through the embankment for the eastern channel and there is believed to be a culvert for the western channel. The dimensions of the existing structures could not be confirmed during the site visit to the Padbury Brook at Twyford due to land access constraints.

6.2.16 There are existing upstream flow restrictions within the catchment of the Padbury Brook throughout this CFA, caused by the embankments and underbridges of the former Great Central Main Line, which runs parallel to the proposed embankment on viaducts. Disused rail underbridges carry the railway over the watercourses approximately 100m south of the proposed Twyford embankment.

Hydrology and hydraulic modelling

6.2.17 The following floodwater levels were extracted from the bespoke hydraulic model at the Twyford west crossing of the Padbury Brook:

- 1 in 100 year annual probability (1%) plus climate change stage of 83.38m AOD; and
- 1 in 1,000 year annual probability (0.1%) stage of 83.46m AOD.

Flood risk to Proposed Scheme

6.2.18 The route will be on viaduct and embankment across the twin channels of the Padbury Brook and its floodplain north of Twyford. The top of rail level across the embankment is 87.3m AOD. The hydraulic modelling shows that for the Proposed Scheme, the minimum top of rail level will be approximately 3.8m above the predicted 1 in 1,000 years return period (0.1% annual probability) floodwater level. As a result, the risk of flooding to the route will be less than 0.1% (low risk). There are no other elements of the Proposed Scheme at this location that will potentially be at risk of flooding.

Padbury Brook at Godington

6.2.19 The Proposed Scheme will cross the Padbury Brook twice more (SWC-CFA13-08 and SWC-CFA13-09) to the north of Godington, as shown on Map WR-01-019, F5 (Volume 5, Water Resources and Flood Risk Assessment Map Book). According to the bespoke modelling of the Padbury Brook and its tributaries, the route will cross Flood Zone 3 on two 75m viaducts and occupy a combined area of 17,000m^2 of Flood Zone 3 and 20,400m^2 of Flood Zone 2. The Padbury Brook has a catchment size of approximately 67.8km^2 at the downstream intersection with the Proposed Scheme, resulting in a 1 in 100 years return period (1% annual probability) flood flow of approximately 11.2m^3/s (calculated using the ReFH). A tributary joins the Padbury Brook between the two crossings.

6.2.20 There is an existing flow restriction in this location caused by the embankments and underbridges of the former Great Central Main Line embankment. Here the Padbury Brook runs parallel to the Proposed Scheme at Godington, approximately 110m upstream of the northern crossing and 60m downstream of the southern crossing of the brook.

Hydrology and hydraulic modelling

6.2.21 The following floodwater levels were extracted from the bespoke hydraulic model at the two Godington crossings of the Padbury Brook:

- 1 in 100 year annual probability (1%) stage of 86.82m AOD and 86.79m AOD upstream and downstream respectively; and
- 1 in 1,000 year annual probability (0.1%) stage of 87.26m AOD and 87.25m AOD upstream and downstream respectively.

Flood risk to Proposed Scheme

6.2.22 The route will be on viaduct and embankment across the main and secondary channel of the Padbury Brook and associated floodplain at Godington. The top of rail level across the embankment is 91.1m AOD. Comparison of the Proposed Scheme with the predicted floodwater levels from the hydraulic modelling shows that the minimum top of rail level will be 3.8m above the predicted 1 in 1,000 years return period (0.1% annual probability) floodwater level. As a result, the risk of flooding to the route will be less than 0.1% (low risk). There are no other elements of the Proposed Scheme at this location that will potentially be at risk of flooding.

Padbury Brook tributary at Barton Hartshorn

6.2.23 According to Environment Agency modelling, the route will occupy approximately 3,000m^2 of Flood Zone 3 and 4,600m^2 of Flood Zone 2 where the Proposed Scheme crosses another tributary of the Padbury Brook (SWC-CFA13-11) between Barton Hartshorn and Newton Purcell, as shown on Map WR-01-019, C5 (Volume 5, Water Resources and Flood Risk Assessment Map Book). This tributary has a catchment size of approximately 3km^2 at the location of the crossing. The intersection with the Proposed Scheme is located where two tributaries combine. Approximately 100m of the northern tributary lies directly beneath the Proposed Scheme and will require diversion.

6.2.24 This watercourse is shown in Environment Agency records to have flooded in 1947.

6.2.25 This tributary was not included within the bespoke hydraulic modelling undertaken as part of the Flood Risk Assessment for the Padbury Brook which focuses on Godington and Twyford downstream of this location. The following flood water levels were therefore extracted from the Environment Agency broadscale model at the crossing of the Padbury Brook tributary at Barton Hartshorn:

- 1 in 100 year return period (1% annual probability) stage of 98.8m AOD; and
- 1 in 1,000 year return period (0.1% annual probability) stage of 98.8m AOD.

6.2.26 The top of rail level at the crossing is 103.8m AOD approximately 5m above the 1 in 1,000 year return period (0.1% annual probability) flood water level. Therefore the Proposed Scheme is not at risk of river flooding in such an event.

6.3 Risk of flooding from surface water

6.3.1 According to surface water flood risk datasets, there are areas within CFA13 that are shown to have a high risk of surface water flooding for both the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events.

6.3.2 The Calvert IMD will cross two watercourses (identified by the Bedford Internal Drainage Board as M23 and M24[18]) that are shown to be at risk of surface water flooding. These watercourses are currently culverted beneath the Bicester to Bletchley railway line embankment, causing a restriction to floodplain flow. Surface water flooding upstream of the Calvert IMD is shown to be relatively deeper and more extensive upstream of the existing rail embankment, with areas of deep (greater than 300mm in depth) flooding. In the vicinity of the IMD, downstream of the existing rail embankment, flood depths are shown to be shallow (between 100mm and 300mm in depth).

6.3.3 There are also areas at risk along the tributaries of the Padbury Brook, upstream of the extent of river flooding close to Twyford and Godington, that have either not been included in the Environment Agency Flood Zone Map or have a catchment size of less than 3km^2.

[18] Bedford Group IDB; Board Area Map; http://www.idbs.org.uk/board-area-map/; accessed: July 2013.

6.3.4 Surface water flooding is also shown for small tributaries of the Padbury Brook upstream of the Flood Zone close to Portway Farm and close to the northern crossing of the Padbury Brook.

Calvert Infrastructure Maintenance Depot

6.3.5 Where the Calvert IMD will cross the easterly of the two watercourses (SWC-CFA13-16), there is an associated Environment Agency Flood Zone, as shown on Map WR-01-019, F3 and F4 (Volume 5, Water Resources and Flood Risk Assessment Map Book). There are extensive mapped areas of surface water flooding from the south, upstream of the extent of the flood zones. The tributary is restricted behind the existing rail embankment and areas of deep flooding are shown on the FMfSW in the 1 in 30 years return period (3.3% annual probability) rainfall event. The width of the surface water flood risk area is also shown to be wider than the flood zone upstream of the existing rail embankment and the proposed IMD.

6.3.6 The FMfSW indicates that, although surface water ponding upstream of the existing rail embankment has the potential to reach depths greater than 300mm, flood water would not overtop the existing embankment in this event. Since the proposed IMD is located on the downstream side of the existing restriction, with the watercourse culverted beneath the IMD extent with surface water managed within the design, there is no significant risk of surface water flooding to the Proposed Scheme.

6.3.7 There is no Environment Agency Flood Zone associated with the westerly of the two watercourses (M23, SWC-CFA13-15) as the catchment draining to the point of the crossing is less than the 3km^2 minimum threshold to be included on the Flood Zone Map. The area, however, is shown to be at risk of surface water flooding both upstream and downstream of the existing rail embankment. The FMfSW shows a wide area of surface water flooding upstream of the embankment. This indicates a 265m wide area at risk of shallow (greater than 100mm but less than 300mm deep) flooding from surface water in the 1 in 30 years return period (3.3% annual probability) event and an extensive area (625m) upstream of the embankment to be at risk in the 1 in 200 years return period (0.5% annual probability) event. The FMfSW shows shallow flooding downstream of the existing rail embankment within the area of the Calvert IMD.

6.3.8 Despite the extensive area at risk of surface water flooding, the depths expected are generally shallow and the FMfSW shows that flooding does not overtop the existing rail embankment. Since the proposed IMD is located on the downstream side of the existing restriction, with the watercourse culverted beneath the IMD extent and with surface water managed within the design, there is no significant risk of surface water flooding to the Proposed Scheme.

6.3.9 A sustainable placement area is proposed upstream of the existing embankment within the area at risk of surface water flooding along the M23 watercourse. The placement area will be raised above existing ground levels and is not expected to be at risk of flooding.

Padbury Brook at Twyford

6.3.10 The FMfSW indicates that there is a dry valley crossed by the Proposed Scheme east of Portway Farm to the east of Twyford. There is a risk of shallow surface water flooding in the 1 in 30 years return period (3.3% annual probability) rainfall event. The dry valley drains north towards the Padbury Brook at Steeple Claydon and will be intersected by the Proposed Scheme in cutting. Surface water runoff within this dry valley will be diverted to ensure there is no risk of surface water flooding to the Proposed Scheme.

6.3.11 The FMfSW indicates areas of shallow flooding from a tributary of the Padbury Brook to the north of Twyford and along the valley of the Padbury Brook in the 1 in 30 years return period (3.3% annual probability) rainfall event along the eastern side of the route. This surface water flooding arises from a dry valley tributary of the Padbury Brook which drains from Cowley Farm towards the main channel and will be crossed by the Proposed Scheme on embankment at Twyford west. This tributary is not included on the Environment Agency Flood Zone Map. Due to complex interactions with the floodplain and restrictions in this location, however, this tributary has been included in the bespoke modelling of the Padbury Brook. The dominant source of flooding at the Twyford area arises from rivers and any risk from surface water will be negligible by comparison.

Padbury Brook at Godington

6.3.12 The FMfSW indicates that there are areas of deep surface water flooding in the 1 in 30 years return period (3.3% annual probability) rainfall event arising from a tributary of the Padbury Brook west of the Proposed Scheme between Godington village and Twyford Mill. This tributary is not included on the Environment Agency Flood Zone Map, however, due to complex interactions with the floodplain and restrictions at Twyford and Godington this tributary has been included in the bespoke modelling of the Padbury Brook. The dominant source of flooding in the Godington area arises from rivers and any risk from surface water will be negligible by comparison.

6.3.13 Potentially deep surface water flooding during the 1 in 30 years return period (3.3% annual probability) event is shown along the length of the tributary which flows from Preston Bissett towards the Proposed Scheme between the two Godington crossings of the Padbury Brook. The FMfSW indicates surface water flooding across a wider area than that shown on the Environment Agency Flood Zone Map. This tributary forms part of the complex floodplain at Godington and is therefore included within the bespoke hydraulic modelling. The dominant source of flooding in the Godington area arises from rivers and any risk from surface water will be negligible by comparison.

6.3.14 The surface water datasets identify a dry valley close to Sunflower Farm, with surface water conveyed north-east to join the Preston Bissett tributary at Chetwode. Shallow surface water flooding is shown along the dry valley in the 1 in 30 years return period (3.3% annual probability) event. The Proposed Scheme is in cutting across the head of this dry valley. The Proposed Scheme includes allowance for overland flows to be collected into land drainage designed to convey the estimated 1 in 100 years return

period (1% annual probability) flood flow including an allowance for climate change, siltation and blockage.

6.3.15 The FMfSW shows the extent of flooding due to rainfall that would occur prior to collection of water into streams of designated drainage infrastructure. By collecting the flows from the watercourses and valley floodplains into an adequately designed land drainage system, the Proposed Scheme will effectively remove the risk of surface water flooding from the point at which the flow would be intercepted for all return period events up to and including 100 years (>1% annual probability). There is a residual risk of the cut-off drain overtopping in more extreme events and the risk of flooding is therefore considered to be 'low risk'.

Padbury Brook tributary at Barton Hartshorn

6.3.16 The Proposed Scheme crosses areas shown on the FMfSW to be at risk of flooding along the Padbury Brook tributary between Barton Hartshorn and Newton Purcell at the point where two valleys combine upstream of the former Great Central Main Line embankment. The embankment forms a restriction to surface water flows and areas of deep flooding are shown behind the embankment.

6.3.17 The extents of flooding shown are within the river flooding extents for the watercourse at the crossing location. Since flooding from surface water runoff occurs early in a rainfall event, it is likely to have receded prior to the onset of any significant river flooding from the watercourse. On this basis, there is unlikely to be any significant cumulative effect due to combined flooding from surface water runoff and from the watercourse that will not already be accounted for in the river flooding analysis of the Padbury Brook tributary. As a result, river flooding will be the dominant source of risk to the Proposed Scheme, with additional surface water flood risks likely to be negligible.

6.4 Risk of flooding from groundwater

6.4.1 The principal underlying geology within the study area is that of the Peterborough member of the Oxford Clay Formation (which is overlain by superficial deposits of mixed glacial material typically consisting of brownish grey mudstone). Near Twyford, superficial river terrace deposits of sand and gravel and river alluvium are present.

6.4.2 To the north of the study area, the Kellaways Formation, which comprises sandstone, siltstone and mudstone, extends into limestone of the Cornbrash Formation. This is overlain in the northern half of the study area by superficial glacial till deposits.

6.4.3 There have been no recorded historical incidents of groundwater flooding within the study area. The BuCC PFRA identifies that a significant proportion of the land (>75%) at the Padbury Brook is susceptible to groundwater emergence. The OCC PFRA identifies that a significant proportion of the land at Godington (>75%) is susceptible to groundwater emergence. The SFRA reports do not identify any specific areas with groundwater flooding risks within the study area. The PFRA dataset is presented at a relatively coarse grid (1km^2) and therefore mapping from the BGS has been used to provide more detailed information regarding the risk of groundwater flooding.

6.4.4 The BGS susceptibility to groundwater flooding map shows that there is a very high susceptibility to groundwater flooding associated with superficial river terrace sand and gravel and river alluvium deposits of the Padbury Brook.

6.4.5 For there to be a risk of flooding from groundwater, the relevant receptor needs to be below ground or at the surface. Consequently, where the Proposed Scheme is raised above surrounding ground, either on embankment or viaduct, the risk of flooding from groundwater is negligible. The Padbury Brook valley, with a very high susceptibility to groundwater flooding, will be crossed on embankment and therefore the risk of flooding to the Proposed Scheme is negligible through the majority of CFA13.

6.4.6 The BGS dataset indicates that there is a very high susceptibility to groundwater flooding within the superficial alluvial deposits along the dry valley that runs east of Portway Farm. The Proposed Scheme is in cutting in this location through the dry valley. Although surface water runoff will be diverted, there may be risk of flooding due to groundwater. The cutting will potentially be flooded during times of high groundwater and, though emergent groundwater will be collected into the track drainage, there is potential for surface ponding within the cuttings depending on the cutting depth and aquifer levels. The Calvert cutting will therefore be at risk of groundwater flooding.

6.4.7 Additionally, a small area surrounding the access track to the west of Twyford is at very high susceptibility to groundwater flooding at the point where the Proposed Scheme moves from embankment to cutting. The cutting will potentially be flooded during times of high groundwater and, though emergent groundwater will be collected into the track drainage, there is potential for surface ponding within the cuttings depending on the cutting depth and aquifer levels. The Twyford cutting will therefore be at risk of groundwater flooding.

6.4.8 The Proposed Scheme will also intersect areas of moderate to high susceptibility to flooding from groundwater within the local superficial glacial till deposits at Chetwode. The length of deep cutting will be at risk of flooding during times of high groundwater, however emergent groundwater will be collected into the track drainage. Further assessment is undertaken in Section 8.

6.5 Risk of flooding from drainage systems

6.5.1 The route will not pass through any urban areas for the full extent within CFA13. There will consequently be no significant risk of flooding from urban drainage within the study area.

6.6 Risk of flooding from artificial sources

6.6.1 Flooding from artificial sources can occur in the event of a failure of impounding or associated infrastructure. The Proposed Scheme will cross an area shown on the Environment Agency RIM to be at risk of flooding in the event of failure of the Tusmore Park Lake, as shown on Map WR-01-018 and Map WR-01-019 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The modelled flow paths from the water body, however, follow the course of the Padbury Brook and its

floodplain. The extent of the area identified as being at risk is significantly less than, and contained within, the floodplain at the crossing location. Therefore all risks and mitigation relevant to the Padbury Brook will also apply to this source of flooding.

6.6.2 A further area will be crossed at the Calvert IMD associated with a risk of flooding due to the failure of the ornamental ponds within the grounds of Claydon House, as shown on Map WR-01-018 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The modelled inundation flow paths show that flow will be restricted behind the existing Bicester to Bletchley railway line embankment, in the same way as surface water runoff. The area at risk of inundation on the downstream side of the existing rail embankment coincides with the risk of flooding from rivers and there is no anticipated additional flood risk arising from artificial sources.

6.6.3 Grebe Lake lies adjacent to the Proposed Scheme; however it is not shown on the Environment Agency maps as having a flood risk associated with failure. The former Great Central Main Line embankment is at approximately 88m AOD adjacent to Grebe Lake, where the water level is approximately 84m AOD. Although the Proposed Scheme will be in cutting, the crest level of the retained cutting will be at the existing embankment level, with any potential flood waters retained behind the raised embankment. There will therefore be no risk of flooding to the Proposed Scheme.

6.7 Summary of baseline flood risk

Table 4: Summary of baseline flood risk for all sources of flooding in CFA13

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
River	Padbury Brook	Very high Flood Zone 3b	Twyford east embankment	Top of rail level will be >1m above 1,000 years return period water level.
			Twyford embankment	
			Twyford west viaduct	
			Cowley embankment	
			Godington east viaduct	
			Godington embankment	
			Godington west viaduct	
			Chetwode embankment	
			Barton Hartshorn north embankment	
Surface water	Agricultural land south of Steeple Claydon (Watercourse M24)	High 30 years FMfSW >0.3m	Calvert IMD	Watercourse will be culverted beneath the IMD and surface water managed by design. No additional risk from upstream due to existing embankment.

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Surface water	Land to east of Calvert (Watercourse M23)	Moderate 200 years FMfSW >0.3m 30 years FMfSW <0.3m	Calvert IMD	Watercourse will be culverted beneath the IMD and surface water managed by design. No additional risk from upstream due to existing embankment.
Surface water	Portway Farm	Moderate 200 years FMfSW >0.3m 30 years FMfSW <0.3m	Calvert cutting	Will be collected by surface water drainage system and diverted to ensure no risk.
Surface water	South of Twyford village	High 30 years FMfSW >0.3m	Twyford east embankment	Top of rail level will be >1m above 1,000 years return period water level.
Surface water	Cowley Farm	Moderate 200 years FMfSW >0.3m 30 years FMfSW <0.3m	Cowley embankment	Top of rail level will be >1m above 1,000 years return period water level.
Surface water	Land south-west of Twyford Mill	High 30 years FMfSW >0.3m	Twyford embankment Twyford west viaduct Cowley embankment	Top of rail level will be >1m above 1,000 years return period water level.
Surface water	Preston Bissett and Chetwode	High 30 years FMfSW >0.3m	Godington east viaduct Godington embankment Godington west viaduct	Top of rail level will be >1m above 1,000 years return period water level.
Surface water	Barton Hartshorn and Barley Fields	High 30 years FMfSW >0.3m	Barton Hartshorn north embankment	Top of rail level will be >1m above 1,000 years return period water level.
Groundwater	Dry valley east of Portway Farm	High susceptibility	Calvert cutting	Groundwater will be collected into surface water drainage system and discharged to local watercourses Top of rail level will be below ground level – at risk.
	West of Twyford	Very high susceptibility	Twyford cutting	
	Glacial till deposits at Chetwode	Moderate-high susceptibility	Chetwode cutting	
Artificial sources	Tusmore Park Lake	Low Within inundation mapping extent	Calvert IMD	Watercourse will be culverted beneath the IMD. No additional risk from upstream due to the existing embankment.

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
	Claydon House ponds	Low Within inundation mapping extent	Twyford east embankment	Modelled risk extent wholly within floodplain of Padbury Brook. Top of rail level will be > 1m above 1,000 years return period water level and therefore above likely water levels within inundation extent.
			Twyford embankment	
			Twyford west viaduct	
			Cowley embankment	
			Godington east viaduct	
			Godington embankment	
			Godington west viaduct	
			Chetwode embankment	
			Barton Hartshorn north embankment	

7 Flood risk management measures

7.1 Risk of flooding from rivers

7.1.1 The Proposed Scheme will be raised above floodplains at crossings such that the risk of flooding from this source is less than 0.1%. Therefore, there are no instances where the Proposed Scheme will be at significant risk of river flooding and consequently no specific mitigation is required.

7.1.2 At all flood zone crossings, replacement floodplain storage will be provided upstream of the Proposed Scheme, or adjacent to the area removed, for losses in river floodplain storage, including embankments and all associated development. Key locations include the Padbury Brook Tributary (M24) at the Calvert IMD, the Padbury Brook tributary at Twyford, the Padbury Brook at Twyford and the Padbury Brook at Godington.

Padbury Brook tributary at Calvert IMD

7.1.3 At the Calvert IMD crossings of the Padbury Brook tributary, replacement floodplain storage will be provided for the eastern crossing (SWC-CFA13-16) to replace the volume of floodplain lost as a result of the embankment, as shown on Map CT-06-055 (Volume 2, CFA13 Map Book).

7.1.4 The Proposed Scheme includes replacement storage downstream of the IMD embankment, on the northern side of the channel.

Padbury Brook tributary at Twyford

7.1.5 At the Twyford east crossing of the Padbury Brook tributary, replacement floodplain storage will be provided to mitigate for the volume of floodplain lost as a result of the embankment, as shown on Map CT-06-056 (Volume 2, CFA13 Map Book).

7.1.6 The Proposed Scheme includes replacement storage upstream of the embankment on the eastern side between the Proposed Scheme and the former Great Central Main Line embankment. A second area has been allocated on the eastern side of the floodplain upstream of the existing rail embankment.

Padbury Brook at Twyford

7.1.7 At the Twyford west crossing of the twin channels of the Padbury Brook, additional floodplain storage will be provided to replace the volume of floodplain lost as a result of the embankment. The Proposed Scheme includes replacement floodplain storage upstream of the former Great Central Main Line, on the western side of the floodplain, as shown on Map CT-06-057 (Volume 2, CFA13 Map Book).

7.1.8 In order to pass under the proposed Twyford west viaduct, the western channel of the Padbury Brook will require a diversion upstream of the embankment and this is included within the design. Additionally, a small tributary which enters the main channels just downstream of the embankment will require diversion.

Padbury Brook at Godington

7.1.9 At the double crossing of the Padbury Brook by the Godington embankment, Godington east viaduct and Godington west viaduct, replacement floodplain storage will be provided upstream of the crossing as shown on Map CT-06-058 (Volume 2, CFA13 Map Book). The Proposed Scheme also includes replacement floodplain storage on the east bank side upstream of the former Great Central Main Line.

7.1.10 In order to pass under the Godington west viaduct, the western channel of the Padbury Brook will require a diversion upstream of the embankment. This is included within the design.

Padbury Brook tributary at Barton Hartshorn

7.1.11 At the Barton Hartshorn crossing of the Padbury Brook tributary, additional floodplain storage will be provided upstream of the crossing to replace the volume of floodplain lost as a result of the embankment, as shown on Map CT-06-060 (Volume 2, CFA13 Map Book). Floodplain storage will also be required for the maintenance access track, which will need to be provided adjacent to the works. Space has been allocated within the design for this additional floodplain storage.

7.1.12 At the Barton Hartshorn embankment, the existing land drain which joins the tributary of the Padbury Brook will require a diversion upstream of the embankment and this is included within the design.

7.2 Risk of flooding from surface water

7.2.1 The extended culvert at the Calvert IMD for the rail head during the seven-year long construction phase will be designed to convey the 1 in 100 years return period (1% annual probability) flood flows including an allowance for climate change.

7.2.2 In all cases where surface water flood flows will be intercepted by the Proposed Scheme floodwaters will be collected in land drainage and conveyed beneath the Proposed Scheme in culverts thus maintaining flood pathways. Potential increases in peak discharge rates will be attenuated prior to release back into the natural drainage network.

7.2.3 The FMfSW shows the extent of flooding due to rainfall that would occur prior to collection of water into streams or designated drainage infrastructure. By collecting the flows from the dry valley into an adequately designed land drainage system, the Proposed Scheme will effectively remove the risk of surface water flooding from the point at which the flow would be intercepted for all return period events up to and including 100 years (>1% annual probability rainfall events) including an allowance for climate change. There is a residual risk of the cut-off drain overtopping in more extreme events.

7.2.4 Measures to manage the risk of flooding from surface water runoff includes:

- provision of replacement floodplain storage and surface water balancing ponds to restrict peak surface water runoff rates to existing greenfield rates;
- culverts designed with adequate capacity to convey the 1 in 100 years (1%

annual probability) flow including an allowance for climate change; and

- culverts designed with internal 600mm freeboard and 300mm allowance for siltation to minimise the chances of blockage or future capacity restrictions.

7.3 Risk of flooding from groundwater

7.3.1 There is potential for surface ponding arising from high groundwater levels within the cutting east of Portway Farm and west of Twyford. Emergent groundwater will be collected into the track drainage system for the Proposed Scheme.

7.4 Risk of flooding from drainage systems

7.4.1 There will be no risk of flooding from drainage systems to the Proposed Scheme, nor any anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. Therefore, no specific management measures will be required.

7.5 Risk of flooding from artificial sources

7.5.1 There are no instances where the Proposed Scheme will be at significant risk of flooding from artificial sources and consequently no specific management measures will be required.

7.5.2 Potential flood water levels and extent arising as a result of breach of the Tusmore Park Lake or Claydon House ponds will be reduced relative to the design river flood in the respective carrying watercourses and therefore replacement floodplain storage provided to mitigate the potential effects of the watercourse crossings will serve to offset any potential effects on the severity of flooding from this source. Due to the extremely low probability of such flooding occurring and the likely low significance of any impacts arising from the Proposed Scheme it is not considered necessary to provide specific mitigation for this scenario.

8 Post-development flood risk assessment

8.1 Local receptors

8.1.1 In addition to the risk of flooding that exists to the Proposed Scheme, there is potential for the Proposed Scheme to affect the risk of flooding to third party receptors by altering flow volumes and mechanics across the range of flood sources. All local receptors with a potential flood risk are identified in Section 5. For the Proposed Scheme to have an impact on a given receptor, the identified pathway for that receptor must be shared by both the subject receptor and the Proposed Scheme, with the result that a number of cases can be excluded immediately. Table 5 summarises the shared pathways between the Proposed Scheme and each receptor and identifies cases where no shared pathway exists.

Table 5: Shared flood risk pathways in CFA13

Local receptor	Vulnerability classification	Source/pathway	Shared pathway between Proposed Scheme and receptor
Properties within the village of Calvert	More vulnerable	Surface water 200 years - deep Groundwater very high	No shared pathway.
Shepherd's Furze Farm	Less vulnerable	Surface water 30 years - deep	Calvert IMD will be immediately downstream of the risk area.
Agricultural land to the south of Steeple Claydon	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Claydon Park Lower Lake Groundwater very high	Calvert IMD will be at this location.
Elm Tree Farm (Agricultural land only)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Claydon Park Lower Lake	No shared pathway.
Lake Farm (Agricultural land only)	Less vulnerable	Surface water 200 years - deep	No shared pathway.
Portway Farm (Agricultural land only)	Less vulnerable	Surface water 200 years - deep Groundwater very high	Embankment exists between the receptor and the Proposed Scheme. No shared pathway.
Properties on Portway Road	More vulnerable	Surface water 30 years - deep	Proposed Scheme embankment will be approximately 1.2km downstream.

Local receptor	Vulnerability classification	Source/pathway	Shared pathway between Proposed Scheme and receptor
Three Bridge Mill	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - shallow Tusmore Park Lake Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain approximately 800m upstream.
Agricultural land east of Twyford (Home Farm)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain at this location.
Playing Fields east of Twyford (off School Lane)	Water compatible	River flooding Flood Zone 3 Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain approximately 160m downstream.
Properties within the village of Twyford	More vulnerable	Groundwater very high	No shared pathway.
Agricultural land owned by Portway Farm (south of Padbury Brook at Twyford) (Agricultural land only)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain at this location.
Agricultural land north and west of Twyford (Church View Farm)	Less vulnerable	River flooding Flood Zone 3 Surface water 200 years - deep Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain at this location.
Cowley Lodge Farm (north of Padbury Brook at Twyford) (Agricultural land only)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain at this location.
The Bungalow (Cowley Lodge)	More vulnerable	Surface water 200 years - shallow	No shared pathway.
Cowley Old House	More vulnerable	Surface water 30 years - shallow	No shared pathway.
Cowley Farm (Agricultural land only)	Less vulnerable	River flooding Flood Zone 3 Surface water 200 years - deep Tusmore Park Lake Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain at this location.

Local receptor	Vulnerability classification	Source/pathway	Shared pathway between Proposed Scheme and receptor
Twyford Mill	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain approximately 1.3km upstream and 950m downstream.
Agricultural land east of Godington (Grange Farm)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain at this location.
Agricultural land north and east of Godington and north of the disused rail lane (Casemore Farm)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain at this location.
Moat Farm	More vulnerable	River flooding Flood Zone 3 Surface water 200 years - shallow Tusmore Park Lake Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain approximately 750m downstream.
Agricultural land and pasture surrounding Chetwode	Less vulnerable	Surface water 30 years - deep Groundwater high	Chetwode cutting may intercept groundwater flows.
Watergate Farm	More vulnerable	River flooding Flood Zone 3 Surface water 200 years - deep Groundwater very high	No shared pathway.
Agricultural land at Barton Grounds Farm	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater very high	Potential effects from Proposed Scheme embankments in the Padbury Brook floodplain at this location.
Barton Grounds Farm	More vulnerable	Surface water 200 years - shallow Groundwater very high	No shared pathway.
Barton Hill Farm	More vulnerable	Groundwater high	No shared pathway.
Manor Farm, Barton Hartshorn	More vulnerable	Surface water 30 years - deep Groundwater very high	No shared pathway.

8.1.2 There is also the potential for the Proposed Scheme to change the baseline risk of flooding described in the Section 6 of this report. Though designed such that the probability of the Proposed Scheme flooding in any given year is less than 1 in 1,000, any change to the baseline risk of flooding could impact on the assessment of flood risk to the Proposed Scheme. All cases of flood risk discussed in Section 6 of this report are therefore reconsidered regardless of the presence or otherwise of third party local receptors.

8.2 Impact on risk of flooding from rivers

Padbury Brook tributaries at Calvert Infrastructure Maintenance Depot

Description

8.2.1 The Calvert IMD temporary rail head will cross two tributaries of the Padbury Brook (SWC-CFA13-15 and SWC-CFA13-16). The Calvert IMD will be built on the eastern side of the Proposed Scheme to the north of, and alongside, the upgraded Bicester to Bletchley railway line embankment, with the temporary railhead occupying a further area of land between the Bicester to Bletchley railway line and permanent features of the Proposed Scheme.

Local receptors and land use

8.2.2 Land use in the area is predominantly arable land and pasture. Local receptors include agricultural land downstream south of Steeple Claydon (moderate value receptor).

Potential effects

8.2.3 The Calvert IMD will cross two tributaries of the Padbury Brook, the larger eastern channel (M24, SWC-CFA13-16) and associated floodplain and the smaller western channel (M23, SWC-CFA13-15), as shown on Map WR-01-018, F3 and F4 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

8.2.4 The IMD will require the extension of the two existing culverts, with culvert lengths of approximately 140m and 130m respectively. An additional 330m length of the newly culverted western channel (M23) will pass beneath the temporary railhead during the construction phase.

8.2.5 Upstream of the rail embankment, an area of sustainable placement is proposed. This will require the diversion of two branches of watercourse M23.

Assessment of effects

8.2.6 Both watercourses will be conveyed beneath the Proposed Scheme in extended culverts, designed to pass their 1 in 100 years (1% annual probability) flood event including climate change flows. Extending an existing culvert would increase friction losses potentially causing a reduction in the conveyance capacity of the watercourse at the Proposed Scheme crossing. Such an effect could potentially lead to an increased risk of flooding upstream with the severity of the effect dependent on the existing culvert gradient and capacity. The proposed extensions however, will have a significantly greater capacity than the current culverts due to their increased size, so it is likely that any such effect will be adequately mitigated.

8.2.7 The IMD and environmental mitigation bund will extend within the floodplain of the eastern watercourse at the Calvert IMD downstream of the existing rail embankment restriction. The proposed embankment will cause a reduction in available floodplain storage and therefore additional replacement floodplain storage will be provided downstream of the embankment extension. The impact on flood risk is therefore expected to be negligible.

8.2.8 Culverting of the M23 watercourse will be extended during the construction period whilst the rail head is in place. This has the potential for a minor adverse impact on downstream surface water flood risk. A flood management plan will be prepared by the contractor as required by the draft CoCP (Volume 5: Appendix CT-003-000) to ensure that the risks and consequences of flooding are managed. The culverting lies downstream of an existing rail embankment and the M23 watercourse is already culverted. Surface water runoff from the rail head will also be managed during construction, with runoff collected and attenuated to existing rates before discharge to local watercourses. Therefore, considering the incorporated mitigation, the impact on surface water flood risk during construction is negligible.

8.2.9 A sustainable placement area is proposed upstream of the existing embankment which will require the diversion of both branches of the M23 watercourses. Diversions will maintain capacity and conveyance in accordance with existing conditions and as a result will not have a significant effect on the risk of flooding from the watercourse.

Padbury Brook tributary at Twyford

Description

8.2.10 The Proposed Scheme will cross a tributary of the Padbury Brook east of Twyford, downstream of the crossing of the former Great Central Main Line embankment. The disused embankment poses an existing restriction to flood flows from the tributary. The Proposed Scheme will be on embankment across the watercourse and associated floodplain, with noise barriers and landscaping bunds adjacent to the embankment. The tributary will require the construction of a 2.1m box culvert beneath the Proposed Scheme. Diversion of the watercourse will be required on the upstream side of the Proposed Scheme to pass through the culvert.

Local receptors and land use

8.2.11 Land use in the floodplain in the vicinity of the crossing is arable farm land and pasture. Local receptors upstream of this crossing include agricultural land east of Twyford at Home Farm (moderate value receptors) and playing fields east of Twyford off School Lane (low value receptor).

Potential effects

8.2.12 The key design elements that have the potential to affect flood flows in the tributary to the Padbury Brook east of Twyford is the Twyford east embankment, with associated infrastructure mitigation earthworks on the upstream side of the proposed embankment and the Twyford east embankment culvert. The Proposed Scheme will obstruct floodplain flows, which could potentially lead to increased water levels upstream of the embankment and increased extent of flooding upstream of the Proposed Scheme.

8.2.13 The Proposed Scheme crosses the tributary close to its confluence with the main channel of the Padbury Brook and interactions between the two watercourses are uncertain. Due to the complexity of the potential impact on flood risk around the Padbury Brook tributary at Twyford, the impact of the Proposed Scheme is assessed through detailed hydraulic modelling.

Assessment of effects

8.2.14 The hydraulic modelling of the Padbury Brook, including the tributary in this location, focusses on the impact of the Proposed Scheme on peak floodwater levels and maximum extents of flooding upstream of the embankment. Baseline modelling was undertaken to include the former Great Central Main Line embankment and culvert beneath, in order to accurately represent existing flood mechanisms. The Proposed Scheme was then modelled including the Twyford east embankment and mitigation earthworks.

8.2.15 There was found to be an increase in flood extents upstream of the Proposed Scheme and an increase in the floodwater level of approximately 160mm for the 1 in 100 years return period (1% annual probability) flood event including an allowance for climate change. This increase is shown to be wholly contained within the area between the proposed embankment and the former Great Central Main Line embankment. Upstream of the existing restriction, there was no change in floodplain extent or depth. More information on the result of the hydraulic modelling for the Padbury Brook can be found in Volume 5: Appendix WR-004-004.

8.2.16 The Proposed Scheme includes replacement floodplain storage to mitigate for the construction of the embankment within the floodplain and to ensure that the Proposed Scheme does not have a significant effect on the agricultural land available between the former Great Central Main Line and the Proposed Scheme.

Padbury Brook at Twyford

Description

8.2.17 The Proposed Scheme will cross the twin channels of the Padbury Brook and floodplain to the west of Twyford, downstream of the former Great Central Main Line rail embankment. The disused embankment poses an existing restriction to out of bank flood flows of the Padbury Brook.

8.2.18 The Proposed Scheme will be on embankment, with a 60m long viaduct spanning the eastern channel. The western channel of the Padbury Brook (SWC-CFA13-05) will require diverting to the east to pass under the viaduct. A third watercourse will be crossed approximately 100m north of the western channel. Proposals are to divert this watercourse around a balancing pond to join the western channel downstream of the proposed crossing.

Local receptors and land use

8.2.19 Land use in the vicinity of the crossing is predominantly arable farm land and pasture. Local receptors upstream and downstream of this crossing include agricultural land (moderate value receptors) and Church View Farm upstream (high value receptor) on the north-eastern side of Twyford village.

Potential effects

8.2.20 The key design elements that have the potential to affect flood flows in the Padbury Brook are the Twyford west viaduct, the Twyford embankment to the east of the viaduct and the Cowley embankment to the west. The viaduct will be 60m long, with two sets of piers located at 20m centres. The Proposed Scheme will obstruct floodplain flows, which could potentially lead to increased water levels and increased extent of flooding upstream of the structure.

8.2.21 Due to the complexity of the potential impact on flood risk around the Padbury Brook at Twyford, the impact of the Proposed Scheme is assessed through detailed hydraulic modelling.

Assessment of effects

8.2.22 The Twyford west and Cowley embankments and Twyford west viaduct will cut off an area of floodplain associated with the twin channels of the main Padbury Brook.

8.2.23 The bespoke hydraulic modelling of the Padbury Brook focusses on the impact of the Proposed Scheme on peak floodwater levels and extents of flooding upstream of the embankment. Baseline modelling was undertaken to include the former Great Central Main Line embankment in order to understand the existing flow mechanics in the vicinity of the crossing. The Proposed Scheme was then modelled by raising both embankments and associated infrastructure mitigation earthworks out of the floodplain. Viaduct piers were also raised, leaving viaduct clear spans modelled as openings within the obstruction. Baseline modelled water levels were then subtracted from the Proposed Scheme levels in order to give the increase in afflux as a result.

8.2.24 It was shown that the proposed viaduct and embankment design throttles the flow of the Padbury Brook twin channels, causing an increase in floodwater levels upstream of the Proposed Scheme. There was found to be an increase in floodwater level of approximately 180mm for the 1 in 100 years return period (1% annual probability) flood event, including an allowance for climate change. This increase is shown to be largely contained within the area between the Proposed Scheme and former Great Central Main Line embankment. There is shown to be a corresponding increase in extent of flooding between the two obstructions, on the eastern side of the floodplain.

8.2.25 Upstream of the existing embankment only a small increase (approximately 30mm) is expected, with minimal increase in extent. More information on the result of the hydraulic modelling for the Padbury Brook can be found in Appendix: Volume 5 WR-004-004.

8.2.26 The Proposed Scheme includes replacement floodplain storage on the west bank upstream of the former Great Central Main Line embankment to mitigate for the loss of floodplain storage as a result of the embankment within the floodplain. This will ensure that the Proposed Scheme does not have a significant effect on the agricultural land between the Great Central Main Line and the proposed route and upstream of the existing embankment. There is no increase in risk to Church View Farm, a high value receptor, as a result of the increase in floodwater level or extent.

8.2.27 Due to the change in flow mechanics as a result of the Twyford embankment and Twyford west viaduct, hydraulic modelling shows a beneficial decrease in floodwater levels on both the western and eastern sides of the Padbury Brook channels as a result of the embankment obstructions in the floodplain. As shown in Figure 13 of Volume 5: Appendix WR-004-004, this results in a reduction in afflux and extent downstream of the route with a moderate to major beneficial impact. This results in a moderate to large and therefore significant beneficial effect on agricultural land associated with Cowley Lodge Farm (CFA13/6), Portway Farm (CFA13/2) and Home Farm, Twyford (CFA13/5).

Padbury Brook at Godington

Description

8.2.28 The Proposed Scheme will be carried over the Padbury Brook at Godington on embankment with two 75m long viaducts. The viaducts will be designed to span the channel and a small section of the floodplain. The majority of the floodplain will be crossed on embankment which lies on the northern side of the former Great Central Main Line embankment.

8.2.29 The western channel of the Padbury Brook (SWC-CFA13-10) will require a minor diversion in order to be conveyed beneath the embankment structure within a culvert. Nearby, a small watercourse (SWC-CFA13-07) will have to be placed in a culvert to allow it to pass below the route.

Local receptors and land use

8.2.30 Land use in the vicinity of the crossing is predominantly arable farmland and pasture. Local receptors include agricultural land between to the north of Godington associated with Casemore Farm (moderate value receptor) and Moat Farm upstream of the Proposed Scheme (high value receptor) and the surrounding agricultural land (moderate value receptor).

Potential effects

8.2.31 The key design elements that have potential to affect flood flows in the Padbury Brook are the Godington east viaduct, Godington embankment, Godington west viaduct and Chetwode embankment.

8.2.32 The downstream viaduct will be supported by fixed abutments and three piers, with pier spacing of 17.5m or 20m. The viaduct design shows the Padbury Brook to pass between the second and third piers (in a northerly direction), however the viaduct does not span the width of the floodplain and as such it will be necessary for all three piers to be within the floodplain. The upstream viaduct also has three piers within the floodplain, with the watercourse passing between the first and second piers (in a northerly direction). The minimum soffit level will be 87.9m AOD.

8.2.33 Due to the complexity of the potential impact on flood risk around the Padbury Brook at Godington, the impact of the Proposed Scheme is assessed through detailed hydraulic modelling.

Assessment of effects

8.2.34 Construction of an embankment and viaduct piers within the floodplain will displace floodwaters, resulting in increased floodwater levels and change in extent of floodplain upstream of the Proposed Scheme.

8.2.35 Baseline modelling was undertaken to include the former Great Central Main Line embankment in order to understand the existing flow mechanics in the vicinity of the crossing. This is particularly complex at Godington due to the double crossing of the watercourse and inflow of the tributary from Preston Bissett between the crossings. The Proposed Scheme was then modelled by including the proposed embankments. Viaduct piers were also raised, leaving viaduct clear spans modelled as openings within the obstruction.

8.2.36 It was shown that the cumulative impact of both viaduct crossings and the embankment within the floodplain, causes an increase in floodwater level and extent upstream of the Proposed Scheme. In the 1 in 100 years (1% annual probability) event (including 20% for climate change) there was found to be a minor increase (approximately 20mm) in floodwater level upstream of Godington east viaduct and embankment, between the two crossings. Upstream of Godington west viaduct there is a moderate increase of 60mm in floodwater level, contained between the Proposed Scheme and former Great Central Main Line.

8.2.37 Land has been allocated to provide replacement floodplain storage to mitigate for the loss of floodplain storage as a result of the embankment and viaduct piers within the floodplain. Replacement floodplain storage is located between the Proposed Scheme and former Great Central Main Line as well as upstream of the former Great Central Main Line. This will ensure that the Proposed Scheme does not have a significant effect on the agricultural land.

8.2.38 There is no increase in risk to Moat Farm, a high value receptor, as a result of the increase in floodwater level or extent.

Padbury Brook tributary at Barton Hartshorn

Description

8.2.39 The Barton Hartshorn embankment will convey the Proposed Scheme over the floodplain associated with the Padbury Brook Tributary (SWC-CFA13-11). The watercourse will be culverted through the new embankment. This culvert will be an extension of the existing culvert which passes through the redundant Great Central Main Line embankment which runs adjacent to the Proposed Scheme in this location.

8.2.40 A maintenance access track is proposed to service balancing ponds and other facilities located on the west side of Barton Hartshorne embankment. This access track will run from School End Road across the Padbury Brook tributary approximately 200m distant from the embankment. The design shows that the access track will be raised on a slight embankment across the floodplain, with a short (approximately 5m long) culvert conveying the watercourse. This culvert will be designed to convey the 1 in 100 years return period (1% annual probability) flood flow including an allowance for climate change.

8.2.41 The eastern side of the Barton Hartshorn embankment for the Proposed Scheme will be within approximately 100m of a watercourse, which runs parallel to the existing Great Central Main Line embankment. This land drain joins the main tributary of the Padbury Brook upstream of the crossing location. This watercourse will be diverted upstream of the Proposed Scheme.

Local receptors and land use

8.2.42 Local receptors in the vicinity of this crossing include agricultural land (moderate value receptors) and woodland (low value receptor).

Potential effects

8.2.43 The key design elements that have potential to affect flood flows in the Padbury Brook tributary south of Barton Hartshorn are the Barton Hartshorn north embankment and Barton Hartshorn embankment culvert.

Assessment of effects

8.2.44 The design for this crossing is a 2,400mm diameter culvert sized to convey the 1 in 100 years return period (1% annual probability) including climate change flood flow of 3.9m^3/s. Extending an existing culvert would increase friction losses potentially causing a reduction in the conveyance capacity of the watercourse at the Proposed Scheme crossing. Such an effect could potentially lead to an increased risk of flooding upstream with the severity of the effect dependent on the existing culvert gradient and capacity. The proposed extension however, will have a significantly greater capacity than the current culvert due to its increased size, so it is likely that any such effect will be adequately mitigated.

8.2.45 The embankment will intrude into the floodplain of this watercourse upstream of the existing culvert, resulting in a loss of floodplain storage. Replacement floodplain storage will be provided upstream of Barton Hartshorn Railway Wood to alleviate any potential increase in upstream floodwater levels resulting from the embankment within the floodplain. Replacement floodplain storage to offset displacement arising from the access track embankment will be provided on the eastern side of the watercourse immediately downstream of the access track. The Proposed Scheme will therefore result in a negligible impact on river flooding from this watercourse.

8.3 Impact on risk of flooding from surface water

8.3.1 The Proposed Scheme will cross a number of small watercourses and land drainage ditches within this CFA outside of the floodplain of the Padbury Brook. The majority are shown on the FMfSW to be at risk of surface water flooding during the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events. All culverts will be designed to accommodate the 1 in 100 years return period (1% annual probability) design flows including an allowance for climate change. Therefore, the impact of the risk of surface water flooding within this CFA during operation is negligible, resulting in a neutral effect on local receptors at all locations, with the following exceptions.

Portway Farm

8.3.2 A culvert will be required to convey the small tributary of the Padbury Brook (SWC-CFA13-02) beneath the Proposed Scheme north of Portway Farm. The Proposed Scheme is in shallow cutting in this location (eastern end of the Calvert cutting). The local receptor upstream of the Portway culvert is agricultural land associated with Portway Farm (moderate value receptor). The culvert will be designed to accommodate the 1 in 100 years return period (1% annual probability) design flows, including a 30% increase to allow for climate change. In addition, this culvert will be located downstream of the existing Great Central Main Line embankment, beneath which the watercourse is currently conveyed in a culvert. Extending an existing culvert would increase friction losses potentially causing a reduction in the conveyance capacity of the watercourse at the Proposed Scheme crossing. Such an effect could potentially lead to an increased risk of flooding upstream with the severity of the effect dependent on the existing culvert gradient and capacity. The proposed extension however, will have a significantly greater capacity than the current culvert due to its increased size, so it is likely that any such effect will be adequately mitigated.

8.3.3 The increased risk of surface water flooding due to the extension of this culvert is therefore negligible, resulting in a neutral effect on local receptors.

8.4 Impact on risk of flooding from groundwater

8.4.1 There are areas within CFA13 that are shown to have a very high susceptibility to groundwater flooding associated with the alluvial and river terrace deposits of the Padbury Brook and associated tributaries. The Proposed Scheme will be either on embankment or viaduct for the crossings of the Padbury Brook and there will therefore be no impact on the risk of flooding from groundwater along these raised sections.

Portway Farm

8.4.2 The Proposed Scheme will be in shallow cutting at the intersection with the area of very high susceptibility to groundwater flooding east of Portway Farm. Susceptibility to groundwater flooding in this area arises from superficial deposits. It is likely that potential for groundwater flooding within this area is closely linked with a small watercourse and the area at risk follows the dry valley downstream to its confluence with the Padbury Brook. Continuity of the watercourse (SWC-CFA13-02) will be maintained through diversion to the west and beneath the Proposed Scheme. It is anticipated that the Proposed Scheme surface water collection system will collect any emergent groundwater into the watercourse. It is therefore likely that the impact on the risk of flooding from this source will be negligible.

Twyford

8.4.3 There is a small area surrounding the access track to the west of Twyford which is at very high susceptibility where the Proposed Scheme falls from embankment into cutting. There is a risk that groundwater will emerge at this point during times of high groundwater. Groundwater ingress will, however, be managed as part of the design

and there will be no significant impact on the risk of flooding to third party receptors arising from the Proposed Scheme.

Chetwode

8.4.4 The Proposed Scheme will be in deep cutting through a large area that has a moderate to high susceptibility to groundwater flooding to the south of Chetwode. This area is associated with superficial groundwater in the glacial till deposits. The cutting could extend through these deposits and into the underlying Oxford Clay.

8.4.5 Groundwater ingress will be managed as part of the design and there will be no significant impact on the risk of flooding to third party receptors arising from the Proposed Scheme.

8.5 Impact on risk of flooding from drainage systems

8.5.1 The Proposed Scheme will not pass through any urban areas for the full extent within CFA13. All highway crossings required will be diverted or re-designed as bridges or underpasses with the exception of those that will be crossed on viaduct, which will remain unchanged. Highway drainage for all new or realigned roads will be designed in accordance with the relevant design guides and regulations and consequently no increase in the risk of flooding arising from overloaded highway drains is anticipated.

8.6 Impact on risk of flooding from artificial sources

8.6.1 Where the Proposed Scheme intersects areas with a residual risk of impounded reservoir failure, the modelled extents of the inundation areas are shown to be within the extent of the Flood Zone Map. The Proposed Scheme has been designed to have no significant impact on the risk of flooding from rivers and any mitigation measures employed apply equally to the effect on the risk of flooding from artificial sources.

8.6.2 The Environment Agency RIM only displays the residual risk of failure of artificial water bodies with a capacity above 25,000m^3, which are covered under Reservoirs Act 1975[19] (as amended by the Flood and Water Management Act 2010[20]). This requires water companies to maintain their reservoirs such that the annual probability of a breach of the reservoir is 1 in 50,000. Although there is a potential impact on the residual risk of flooding from the reservoir the likelihood of such flooding occurring is extremely low.

8.6.3 The impact of the Proposed Scheme on the actual risk of flooding from impounded reservoir failure will be negligible.

[19] *Reservoirs Act 1975* (c.23). London, Her Majesty's Stationery Office.
[20] *Flood and Water Management Act 2010* (c.29). London, Her Majesty's Stationery Office.

8.7 Summary of potential impacts and effects on flood risk

Table 6: Summary of potential flood risk impacts and effects in CFA13

Receptor	Vulnerability classification	Pathway	Impacts and effects
General Proposed Scheme		River flooding	Significant changes in hydraulics along the Padbury Brook, no overall effect expected. No significant effect expected as a result of Barton Hartshorn tributary crossing.
		Surface water	No significant effects expected.
		Groundwater	No significant effects expected.
		Drainage systems	No effects expected.
		Artificial sources	No additional effects expected above those addressed by river and surface water flooding.
Shepherd's Furze Farm	Less vulnerable	Surface water 30 years - deep	No significant effects expected.
Agricultural land to the south of Steeple Claydon	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Claydon Park Lower Lake	No significant effects expected.
Properties on Portway Road	More vulnerable	Surface water 30 years - deep	No significant effects expected.
Three Bridge Mill	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - shallow Tusmore Park Lake	No significant effects expected.
Agricultural land east of Twyford (Home Farm)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep	Major beneficial impact on agricultural land north of the Proposed Scheme downstream of the Twyford west embankment and viaduct crossing and the Twyford east embankment. Reduction in floodwater levels and extents as a result of the Proposed Scheme.
Playing fields east of Twyford (off School Lane)	Water compatible	River flooding Flood Zone 3	No significant effects expected.

Receptor	Vulnerability classification	Pathway	Impacts and effects
Agricultural land owned by Portway Farm (south of Padbury Brook at Twyford) (Agricultural land only)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep	Major impact on agricultural land upstream of Twyford east embankment, between the Proposed Scheme and former Great Central Main Line embankment. Replacement floodplain storage provided to mitigate impact. Major beneficial impact on agricultural land north of the Proposed Scheme downstream of the Twyford west embankment and viaduct crossing. Reduction in floodwater levels and extents as a result of the Proposed Scheme.
Agricultural land north and west of Twyford (Church View Farm)	Less vulnerable	River flooding Flood Zone 3 Surface water 200 years - deep	Minor adverse impact on agricultural land upstream of the former Great Central Main Line embankment as a result in Twyford embankment and Twyford west viaduct crossing. Replacement floodplain storage provided to mitigate impact.
Cowley Lodge Farm (north of Padbury Brook at Twyford) (Agricultural land only)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake	Minor to moderate adverse effect expected on floodplain downstream of Twyford embankment and Twyford west viaduct crossing, between the twin channels. Replacement floodplain storage provided to mitigate impact. Major beneficial impact on agricultural land north of the Proposed Scheme immediately downstream of the Twyford embankment and viaduct crossing on the western side of the Padbury Brook. Reduction in floodwater levels as a result of the Proposed Scheme.
Cowley Farm (Agricultural land only)	Less vulnerable	River flooding Flood Zone 3 Surface water 200 years - deep Tusmore Park Lake	No significant effects expected.
Twyford Mill	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake	No significant effects expected.
Agricultural land east of Godington (Grange Farm)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake	No significant effects expected.

Receptor	Vulnerability classification	Pathway	Impacts and effects
Agricultural land north and east of Godington and north of the disused rail embankment (Casemore Farm)	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Tusmore Park Lake	Minor to moderate impact expected as a result of Godington embankment with viaducts within the floodplain. Replacement floodplain storage provided to mitigate impact.
Moat Farm	More vulnerable	River flooding Flood Zone 3 Surface water 200 years - shallow Tusmore Park Lake	Major impact anticipated on agricultural land upstream of former Great Central Main Line embankment as a result of Proposed Scheme crossings at Godington. Replacement floodplain storage provided to mitigate impact. No significant effects expected as far upstream as the property at Moat Farm.
Agricultural land and pasture surrounding Chetwode	Less vulnerable	Surface water 30 years - deep Groundwater high	No significant effects expected.
Agricultural land at Barton Grounds Farm	Less vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep	No significant effects expected.

9 Conclusions

9.1 Summary

9.1.1 The Proposed Scheme within CFA13 extends from the Calvert Green parish boundary in the south to the Barton Hartshorn parish boundary in the north. The study area includes all areas within 1km of the Proposed Scheme which includes areas at risk of flooding from various sources, as follows:

- areas at risk of river flooding from the Padbury Brook;
- areas at risk of flooding arising from surface water and minor watercourse crossings;
- areas susceptible to groundwater emergence and thus at risk of groundwater flooding; and
- areas at risk of inundation should the impounding embankments of Claydon Park Lower Lake or Tusmore Park Lake fail.

9.1.2 The Proposed Scheme will be at least 1m above design floodwater levels within all areas at risk of flooding from rivers, drainage and artificial water body sources, or include mitigation within the design to manage flooding. Residual risks from these sources will be negligible. Design standards are such that no flooding of the Proposed Scheme will be expected in the design flood events under normal operating conditions.

9.1.3 In order to prevent general impacts on flood risk and river morphology resulting from the Proposed Scheme, the following general mitigation will be included:

- provision of replacement floodplain storage to prevent displacement of floodwaters within areas at risk of flooding from rivers;
- provision of storage and surface water balancing ponds to maintain peak flows and volumes collected within the Proposed Scheme within existing discharge parameters;
- design of culverts with internal headroom and allowances for siltation to minimise the chances of blockage or future capacity restrictions; and
- inclusion of a 30% allowance for climate change on all design rainfall events and 20% on all river flows.

9.1.4 Aside from agricultural land immediately adjacent to the Proposed Scheme along the Padbury Brook corridor, where there will be localised changes in flood level and extent, there will be no significant additional risks or effects arising from the Proposed Scheme in relation to the risk of flooding from the Padbury Brook or its tributaries, as a result of the following design measures:

- replacement floodplain storage will be provided at the Calvert IMD to offset losses encountered as a result of the floodplain crossing;

- watercourse diversions upstream of the IMD will be designed to maintain conveyance and capacity to ensure no increase in depth, extent, frequency or duration of flooding;
- replacement floodplain storage will be provided upstream of the proposed crossing of the Padbury Brook tributary at Twyford to offset any losses in floodplain storage or conveyance capacity that arise due to the proposed embankment and culvert;
- replacement floodplain storage will be provided upstream of the proposed crossing of the Padbury Brook at Twyford to offset any losses in floodplain storage that arise due to the proposed embankment and piers within the floodplain;
- replacement floodplain storage will be provided upstream of the proposed western crossing of the Padbury Brook at Godington both between the proposed embankment and former Great Central Main Line and upstream of the former Great Central Main Line; and
- replacement floodplain storage will be provided both upstream and downstream of the proposed crossing of the Padbury Brook tributary at Barton Hartshorn to offset any losses in floodplain storage or conveyance capacity that arise due to the proposed embankment and access track within the floodplain.

9.2 Residual flood risks to Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios, for example when a culvert becomes blocked causing flooding upstream. All design is generally undertaken assuming that existing infrastructure is functioning under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from rivers

Padbury Brook tributaries at Calvert IMD

9.2.2 The extension to the existing culverts at the Calvert IMD will be designed including allowances for siltation and blockage. Consequently the risk of culvert failure causing an increase in existing flood risk as a result of the Proposed Scheme will be negligible. There will remain a residual risk arising from potential blockage of the existing culvert, although it is likely that the existing Bicester to Bletchley railway line embankment would prevent flood waters from reaching the IMD.

Padbury Brook tributary at Twyford

9.2.3 The Proposed Scheme conveys the tributary to the Padbury Brook beneath the embankment and adjacent noise barriers and landscaping bunds in a rectangular box culvert. In order to pass beneath the entirety of the width of the Proposed Scheme in this location, a 100m long culvert will be required. There will therefore be a residual risk arising from potential blockage of the culvert causing backing up of floodwater.

The detailed design will make provision for ensuring that blockages are prevented and maintenance access for clearing is possible.

9.2.4 In addition, the top of rail level of the Twyford east embankment is approximately 3.8m above the 1 in 1,000 year floodwater level and therefore even in the event of complete blockage of the culvert; floodwater is unlikely to pose significant additional risk to the Proposed Scheme.

Padbury Brook at Twyford

9.2.5 The Proposed Scheme crosses the Padbury Brook on viaduct, with piers located within the floodplain. The 60m wide structure will be greater than 4m above surrounding ground level, with piers spaced at 20m intervals. Therefore, blockage of the viaduct spans is unlikely. There is a freeboard of approximately 3.8m for the top of rail level and the 1 in 1,000 years floodwater level and hence the residual risk of flooding to the scheme is minimal as a result. Access to the banks of the Padbury Brook will be available beneath the Twyford west viaduct structure for clearing and maintenance work.

Padbury Brook at Godington

9.2.6 The Proposed Scheme crosses the Padbury Brook twice at Godington, on two 75m wide viaducts with piers located within the floodplain. Both structures are greater than 5m above the level of the surrounding floodplain and therefore blockage of the viaduct spans is unlikely. Two culverts beneath the proposed embankment are required; a 2.1m box culvert (Godington embankment north culvert) and a 1.8m box culvert (Godington embankment south culvert). There will therefore be a residual risk arising from potential blockage of these culverts causing backing up of floodwater. The detailed design will make provision for ensuring that blockages are prevented and maintenance access for clearing is possible.

9.2.7 In addition, there is a freeboard of approximately 3.7m above the 1 in 1,000 years floodwater level and hence the residual risk of flooding to the scheme as a result of blockage is minimal as a result. Access to the banks of the Padbury Brook will be available beneath both Godington east and west viaduct structures for clearing and maintenance work.

Padbury Brook tributary at Barton Hartshorn

9.2.8 The extension to the existing culvert beneath the former Great Central Main Line embankment at Barton Hartshorn is designed with minimum internal headroom of 600mm above the design flood water level to minimise the risk of blockage. There is therefore not expected to be any significant increased risk of flooding arising from potential blockage of culverts.

Residual flood risks from surface water and minor watercourses

9.2.9 All culverts within the Proposed Scheme are designed with minimum internal headroom of 600mm above the design floodwater level to minimise the risk of blockage. There is therefore not expected to be any significant increased risk of flooding at minor watercourses and dry valley crossings arising from potential blockage of new culverts. Where culverts are extended, there is a potential residual

flood risk to the Proposed Scheme arising in the event of blockage of the existing culverts. This is addressed within the river sources risks in Section 9.2.

9.2.10 There are no other minor watercourse crossings within CFA13 where significant hydraulic structures exist within a reasonable hydraulic distance either upstream or downstream which could create significant additional risks of flooding to the Proposed Scheme due to blockage or failure.

Residual flood risks from groundwater

9.2.11 Groundwater levels rise and fall relatively slowly and for any change to occur in the risk of flooding from this source below ground intervention is required. The risk of flooding from groundwater already considered therefore presents an absolute risk and there are no significant residual risks arising from this source.

Residual flood risks from drainage systems

9.2.12 There are no areas within CFA13 where a significant risk of flooding exists from drainage systems or artificial sources. Consequently, there are no expected residual risks from these sources.

Residual flood risks from artificial and surface water bodies

9.2.13 Within CFA13 the Proposed Scheme crosses the inundation areas associated with failure of the impounding embankments of Claydon Park Lower Lake and Tusmore Park Lake. The Environment Agency methodology considers the consequences of total failure of the reservoirs and therefore no further residual risks arise.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 Following mitigation for impacts on the risk of flooding arising from the Proposed Scheme, there will be residual effects on the risk of flooding due to changes to geometry, floodplain flow characteristics and river morphology at the Padbury Brook. Such effects will be limited to the reshaping of floodplain extents arising from additional floodplain storage and river diversion works.

9.3.2 All culverts within the Proposed Scheme are designed to convey the 1 in 100 years return period (1% annual probability) flow including an allowance for climate change with minimum internal headroom of 300mm above the design floodwater level to minimise the risk of blockage. Consequently, there will be a negligible increase in upstream residual flood risks arising from the introduction of culverts within the Proposed Scheme.

9.4 Compliance with local planning policy

9.4.1 The Proposed Scheme includes an allowance for future increases in the risk of flooding as a result of climate change by adding a 20% increase to design river flows and a 30% increase to rainfall intensities and flows in minor watercourses as recommended in the NPPF Technical Guidance document. SuDS, in the form of open channel land drainage, balancing ponds and swales are used throughout the design. Several local planning policy documents state that all development proposals require detailed drainage design and the use of SuDS to reduce the rate and volume of

surface water runoff. The Proposed Scheme will therefore be in compliance with the AVDC SFRA, AVDC WCS and the BuCC LFRMS.

9.4.2 The location of the Proposed Scheme within areas of flood risk and the inevitable loss in natural floodplain capacity is at variance with the general aims of internal drainage board policy. Construction within the floodplain is contrary to Bedford Internal Drainage Board bylaws. In addition, Cherwell Local Plan Policy EN14 aims to prevent development in areas of flood risk. There is, however, no practical way to avoid a certain amount of floodplain flow obstruction due to the linear nature of the Proposed Scheme. The Cherwell and West Oxfordshire joint SFRA aims to manage future flood risk by promotion of the protection of floodplains from development. It states, however, that where floodplain development is inevitable level-for-level replacement floodplain storage should be provided. The SFRA further recommends that strategic infrastructure is located within areas with the lowest risk of flooding.

10 References

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